

## “TECH NOTES”

“**TECH NOTES**” is an effort by the FOSSC Materials Laboratory to share design and construction technology gained from projects done throughout WSDOT. This issue is from the Pavements Branch discussing concrete intersections.

### Design and Construction of Concrete Intersections

The Washington State Department of Transportation (WSDOT) began replacing selected flexible pavement intersections with Portland cement concrete pavement (PCCP) in 1994. These asphalt concrete pavement (ACP) intersections were severely rutted and distressed from loads, slow moving vehicles, and warm temperatures.



Distressed pavement on SR 395 in Kennewick, Washington.

Though WSDOT has considerable experience with cement concrete pavements, a unique feature was the replacement of existing ACP at intersections on urban arterials. Seventeen intersections have been reconstructed with PCCP as of September 2001.

Both PCCP and ACP have 40-year design lives, however, the PCCP requires very minimal, if any future rehabilitation. The construction user costs and disruption to traffic

that are necessary with future ACP inlays during its design life are reduced when PCCP is used. The major disadvantage with PCCP intersections is the higher initial construction cost. However, a life cycle cost analysis of PCCP reconstruction versus ACP reconstruction and future inlays shows that PCCP intersection reconstruction competes with, and can be less expensive than,



Concrete intersection on SR 2 in Spokane, Washington.

rebuilding with ACP over a 40-year period.

Several municipalities in the State of Washington including the City of Kennewick, City of Seattle, City of Spokane, and Spokane County, have successfully completed PCCP intersection projects. The PCCP intersection projects for the City of Kennewick, City of Spokane and Spokane County were selected primarily to eliminate chronic rutting problems. PCCP intersections within the City of Seattle

were a result of its PCCP construction program on many arterials.

The main reasons for not considering PCCP reconstruction prior to 1994 was related to constructibility and concerns about accommodating high traffic flows through urban intersections. Rehabilitating urban intersections with ACP requires rotomilling and inlaying with ACP to remove wheel rutting. This work can typically be done at night, in a short period, and with a minor inconvenience to the public, but must be performed every eight to ten years or earlier. On the other hand, rehabilitating intersections with PCCP usually involves disruption of the intersection, and can include complete closure of the intersection or alternating lane closures.



Placement of formwork prior to a PCCP intersection pour.

The concern within WSDOT was that the inconvenience to the users was too great to construct urban intersections with PCCP. However, since 1994, WSDOT has shown that PCCP intersections are constructible and the early concerns have been overcome. WSDOT has built PCCP intersections with an average daily traffic approaching 37,000 on the major leg of the intersection.

A comparison of initial PCCP intersection costs ranged from \$455,500 to \$982,200 for PCCP and \$349,800 to \$728,600 for ACP.

The range in the PCCP or ACP reconstruction costs resulted primarily from the size and



Placement of concrete using a Whiteman Screed at an urban intersection.

variability in unit bid prices for each intersection. Typically, intersection sizes ranged from 4,100 to 6,700 square yards. With the smaller intersections, the unit bid costs typically increased, which drives the costs for reconstruction up. On average, initial construction costs for full depth PCCP reconstruction at urban intersections were 25 to 30 percent more than full depth ACP reconstruction.

The cost per square yard for the initial PCCP construction ranged from \$66 to \$148 per square yard, whereas ACP intersection costs ranged from \$51 to \$109 per square yard. The PCCP reconstruction costs were less when the intersections were reconstructed as part of a larger asphalt resurfacing project.

The 40-year annualized costs for intersections show that full depth PCCP intersection reconstruction is typically less than full depth ACP reconstruction when future ACP inlays are accounted for. A study of six of the intersections reconstructed with concrete showed that five of the six cost from 6 to 14 percent less than ACP reconstruction (see Table 1 and Figure 1).

In comparison the 40-year annualized cost for reconstructed PCCP intersections compared to ACP inlays at four-, six- and eight-year cycles show that the ACP inlay will always be less than the PCCP reconstruction (see Table 2).

However, the state or local agency must decide whether ACP inlays meet the expectations of the public. The public view of an agency rehabilitating the same section of roadway at four-, six- or eight-year cycles does not reflect well on the agency.

Table 1. Annualized costs (40-years) for PCCP reconstruction versus ACP reconstruction with inlays at 8-year cycles.

SR	Intersection	PCCP Rebuild	ACP Rebuild with Inlays at 8-year Cycles
27	Sprague	33,000	34,800
90	Broadway	27,600	51,500
2	Francis	72,100	80,500
291	Maple/Ash	32,900	35,500
27	Broadway	43,200	38,500
395	19th	30,100	34,300

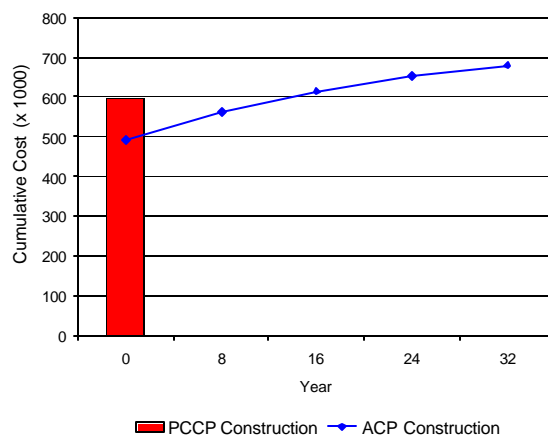


Figure 1. Cumulative costs (present worth) for initial PCCP construction and initial ACP construction with inlays at 8-year cycles over a 40-year period.

Table 2. Annualized costs (40-years) for PCCP reconstruction versus ACP inlays at 8-year cycles.

SR	Intersection	PCCP Rebuild	ACP Inlays at 8-year Cycles
27	Sprague	33,000	12,300
90	Broadway	27,600	14,900
2	Francis	72,100	24,500
291	Maple/Ash	32,900	15,200
27	Broadway	43,200	14,500
395	19th	30,100	14,400

Traffic control and construction staging is a primary issue associated with the construction of PCCP intersections. While some delay to the traveling public is unavoidable, the delay has proved to be tolerable even with limited or complete closures. An important design element is to obtain input from any party that will be affected by the intersection reconstruction. These parties include, but are not limited to, local governments, fire and police agencies, business owners, and private citizens. An important element to contract administration has been the wide publicity by WSDOT Public Information to local governments, businesses, and to the media, including newspapers and radio.

The Customer Focus Highway Construction Workshop, held in Seattle in January 1999, noted that the traveling public is a lot more tolerant during construction when people are kept informed. With widespread publicity, WSDOT has noticed decreased traffic volumes during intersection reconstructions. The reduction represents people who have found alternative routes or have adjusted their schedules to avoid the construction project.

Staging options for PCCP intersection construction include complete closures, partial closures, construction under traffic, complete closures during limited time periods, and any combination of the above.



WSDOT has used complete closures, partial closures with detours, construction under traffic and a combination of construction under traffic and complete closures.

The ideal construction situation is to completely close the roadway. Complete closures allow the contractor to remove and replace more roadway in a continuous and safe operation. Interaction with traffic is avoided and complicated work zone lane configurations are eliminated. Complete closures also restrict access to businesses that are adjacent to the intersection and are therefore unpopular. However, closing a major urban arterial is often not an option, particularly when detours are not available.

The South Central Region used complete closures on SR 395 in Kennewick, where the Clearwater Avenue, West Kennewick Avenue, and the Yelm Street intersections were reconstructed. One intersection per weekend was reconstructed during September and



Construction under traffic at an urban intersection.

October 2000. The contract specified closing each intersection by 7:00 p.m. Thursday evening and opening to traffic by 6:00 a.m. the next Monday morning. Local traffic was detoured to adjacent streets, while state highway traffic was detoured over nearby Interstate Highways.



Concrete intersections constructed in Kennewick, Washington.

Before the weekend closures, the approach and leave legs to the intersections were reconstructed under traffic. During the weekend closures, the contractor removed and replaced the roadway within the intersection square (radius return to radius return) and a portion of each approach or leave legs of the adjoining city streets. PCCP placement and curing proceeded well, with the roadway opened well ahead of the 6:00 a.m. Monday morning target. Following the closures, WSDOT received very favorable comments from both businesses and residents.

Full documentation of the Kennewick area accelerated reconstructions including a video and construction report will be available through the Innovative Pavement Research Foundation.

Design and construction considerations, PCCP intersection construction costs, life cycle costs, traffic management, and quality control issues are detailed in WSDOT's May 2001 publication WA-RD 503.1 "PCCP Intersections – Design and Construction in Washington State." This report can be obtained from the WSDOT Research Office or from the contact provided below.

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